BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D.C. 20024

SUBJECT: Analysis of Work/Rest Cycles in the Lunar Environs for the H1 Mission - Case 320

DATE: April 23, 1969

FROM: P. Benjamin

ABSTRACT

The sequencing of work and rest periods between Lunar Orbit Insertion (LOI) and Trans Earth Injection (TEI) for the H1 mission is examined in detail. Three configurations, each using a 2:1 ratio of work to rest, are examined--the normal 16/8 work/rest cycle, 8/4 work/rest on the surface, and a full 8/4 cycle throughout. Evaluation of the possible permutations relates timeline scheduling to crew performance.

It is concluded that for a full 16/8 cycle, sleep between the two scheduled EVA's and in orbit prior to TEI provides the best probability of high crew performance. With an 8/4 cycle on the surface only, sleep before EVA plans are preferred. The full 8/4 mode has only a single plan with no options, as a result of the requirement to sleep before and after each block of activities. This cycle, with three lunar surface sleep periods, provides acceptable performance at the expense of a longer surface stay.

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MEMORANDUM FOR FILE

Introduction

In considering possible work/rest cycles in the lunar environs for the H1 mission, three configurations are examined here, each using a 2:1 ratio of work to rest. The first mode uses a 16/8 work/rest cycle similar to a normal earth working day. The second uses the 16/8 cycle in lunar orbit and an 8/4 work/rest cycle on the surface. The third mode uses an 8/4 cycle throughout. Emphasis is upon examination of the effects of scheduling the surface sleep period (or periods) before, after, or between the two EVA's. All possible permutations are examined and evaluated using the techniques and restrictions described in a previous memorandum by the author.* No distinction is made between preplanned timelines and real time modifications, although the combinations presented include both sets.

Timelines

The timeline prior to TD is held invariant for all permutations except for the full 8/4 cycle configuration. A two-burn LOI and split LM activation and checkout with a 7.5 hour sleep period between the two portions of checkout are assumed. Time awake at TD is taken as 6.5 hours for all modes, and the first option point is at the completion of post TD checks and eating, 2 hours after TD.

Figure 1 shows the options available with a 16/8 work/rest cycle. Either EVA or sleep may follow the post TD checks. If sleep occurs at this point, both EVA's must follow and no further options are available. Designating an EVA with a letter "E" and a sleep period with an "S" this option may be identified as SEE to show that a sleep period is followed by two EVA's. If EVA occurs first on the surface two further options are available. Sleep may fall between the two EVA's (option ESE) or after the EVA's (option EES). A similar set of alternatives is available at the completion of docking and IVT. Sleep may

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*P. Benjamin, "An Analysis of Work/Rest Cycles and Crew Performance for Various Lunar Environs Timeline Configurations," Bellcomm Technical Memorandum TM-69-2033-1, March 3, 1969.

either precede or follow TEI. Designating TEI with a "T" the two permutations available for the sleep first on the surface option may be coded as SEETS and SEEST. The six permutations of the 16/8 work/rest cycle are evaluated below.

If a 16/8 work/rest cycle is to be maintained in orbit but an 8/4 cycle adopted on the surface the combinations available are presented in Figure 2. The timeline prior to TD and following LO is identical to that shown for the full 16/8 cycle case discussed above. The surface timeline allows two short "catnaps" of 4 hours duration either to precede or to follow the two EVA's.

Only one timeline is possible when the 8/4 work/rest cycle is used throughout as shown in Figure 3. In this case there are three sleep periods on the surface, extending the lunar surface stay time. A short sleep period must also precede (and another follow) TEI.

Evaluation

As is clear from the time matrix, Table 1, two lunar orbit times result from most of the permutations studied. The shorter time of 58 hours corresponds in all cases to the use of a sleep after TEI option and the longer 66 hour time results from a sleep before TEI option. The full 8/4 cycle lunar orbit time falls between these two times, at 62 hours. Thus if a short lunar orbit time is desired the sleep after TEI option must be adopted.

A lunar surface stay time of 28 hours results in all cases except the full 8/4 cycle, which requires the extra 4 hours associated with the third sleep period. Thus positioning of the sleep periods does not affect the length of the surface stay.

An examination of the longest and shortest days, indicated in Table 1, shows that only the ESEST option of the 16/8 mode adheres to the nominal work/rest cycle. The ESETS and SEETS options both have long LO days, since there is no sleep period between the last EVA and TEI. The two options which only schedule sleep after completion of both EVA's, EESST and EESTS, have long TD days, and the remaining permutation, SEEST, schedules both EVA's and ascent into a long LO day.

For the mode which switches to an 8/4 cycle on the surface the long day is TD day for the two ES options and LO day for the two SE options. In all cases an 8 hour sleep period either precedes or follows the long day. Thus in three of the four cases the long 16 hour day shown in Table 1 occurs in the transition between the 16/8 and 8/4 cycles. The fourth case has a very long, non-nominal day even for a 16/8 cycle.

The possibility of performance decrement due to longer than nominal times awake at critical events is reflected in the lower portion of Table 1. The two 16/8 cycle plans which perform two EVA's before sleeping each show the possibility of reduced performance level during the second EVA. The plan which calls for sleep before both EVA's results in a large awake time at docking, a very critical maneuver, while in the ESETS plan, TEI, the least demanding event listed, in terms of crew performance, is scheduled at the end of a long day. Of the 16/8 work/rest cycle permutations only ESEST provides nominal performance (as reflected in awake times) throughout.

Of the plans which provide an 8/4 cycle on the surface only, docking is performed 13 hours after a short 4 hour sleep for both plans which sequence the "catnaps" before EVA. In addition, the SE,TS plan calls for TEI 18.75 hours after a short sleep. Thus the EVA first 8/4 surface cycle plans provide the best probability of high crew performance. The ES,ST option provides very good performance predictions and the ES,TS option, with a shorter lunar orbit time, is off nominal only with an 11.25 hours awake figure at TEI. The full 8/4 cycle throughout results in excellent time since sleep figures at all events.

Summary

If only a 16/8 work/rest cycle is permitted on the H1 mission, sleeping between the two EVA periods and in orbit prior to TEI provides the best probability of high crew performance. If an 8/4 cycle is adopted on the lunar surface only, plans which have sleep scheduled after EVA result in better performance figures than sleep before EVA plans. Sleep before TEI for these plans provides nominal performance throughout, while sleep after TEI results in a shorter lunar orbit time but a slightly higher chance of decreased performance at TEI. If an 8/4 work/rest cycle is adopted throughout the lunar environs timelines, good performance figures at all events result, but the three surface sleep periods result in a longer lunar surface stay.

2033-PF-scs

P. Benjamin

Attachments
Figures 1, 2, 3
Table 1

Copy to:
(See next page)

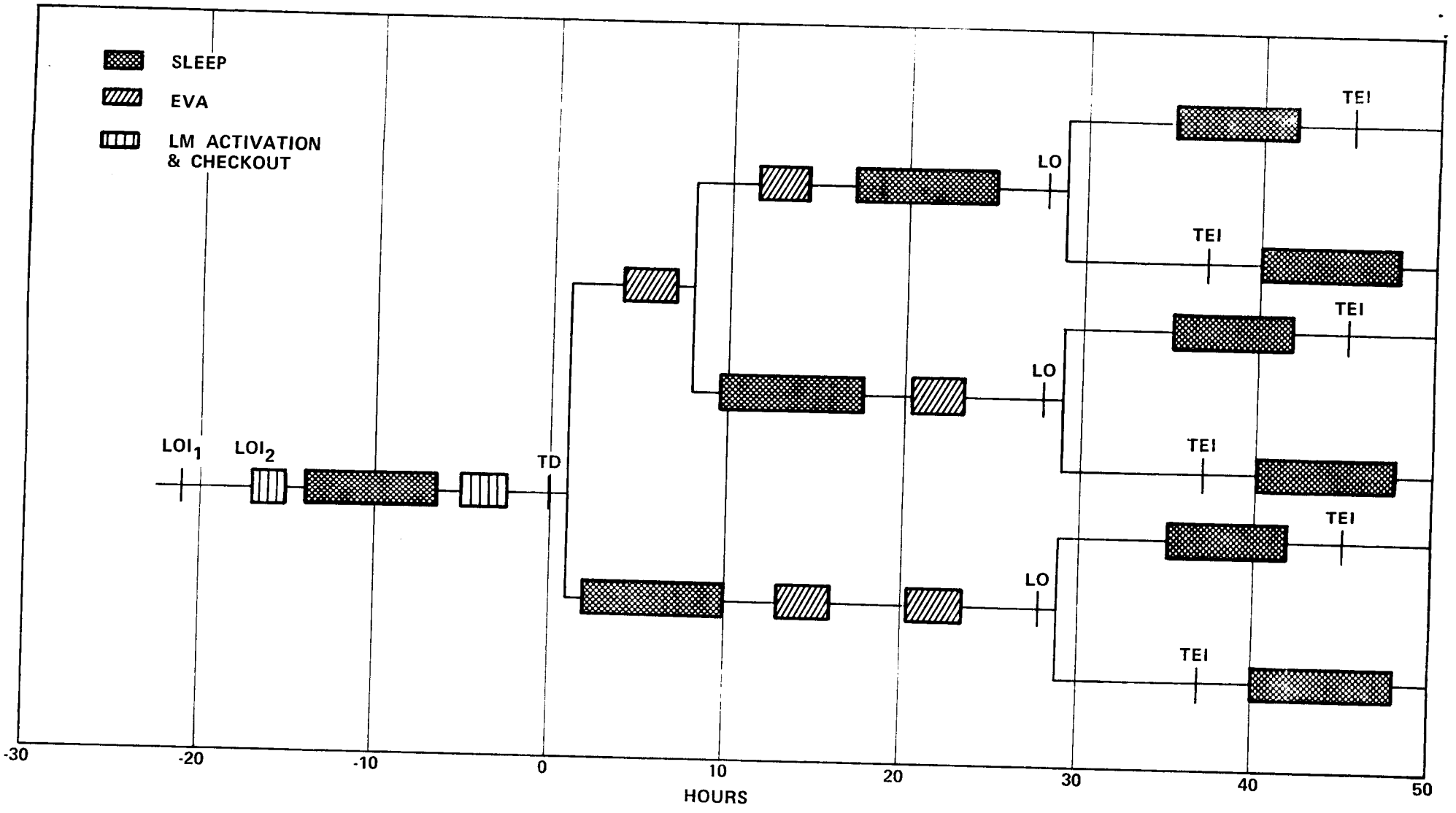

FIGURE 1 - 16/8 WORK/REST CYCLE THROUGHOUT

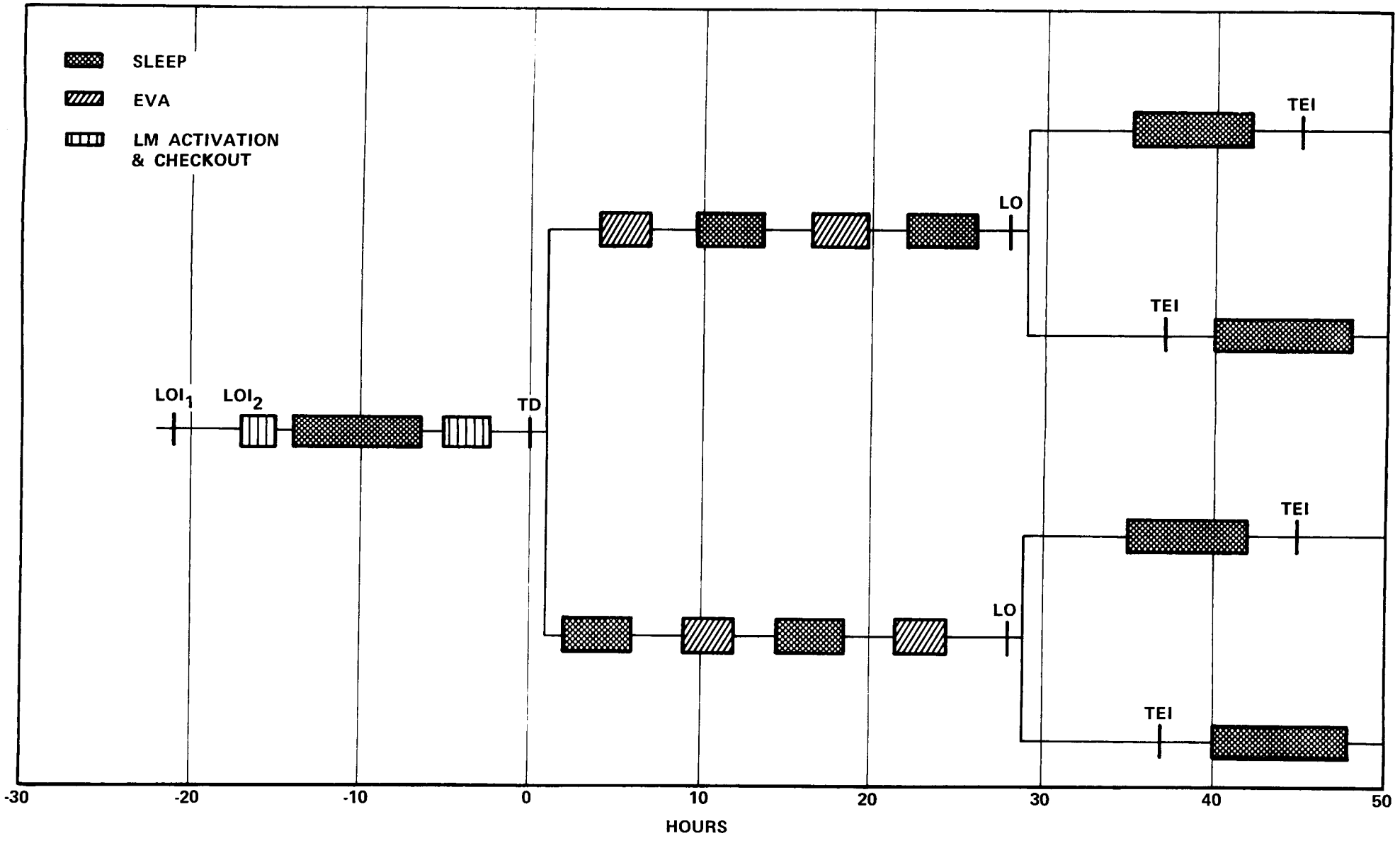

FIGURE 2 - 16/8 CYCLE WITH 8/4 WORK/REST ON SURFACE

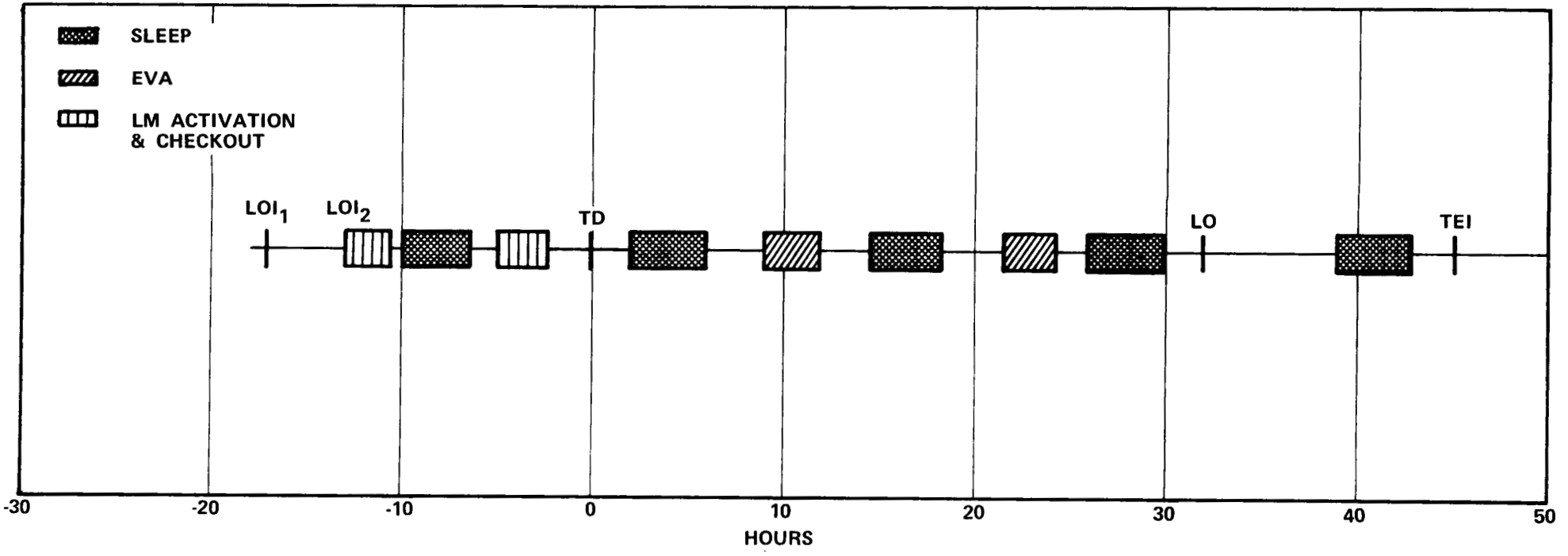

FIGURE 3 - 8/4 WORK/REST CYCLE THROUGHOUT

	16/8 CYCLE						SURFACE 8/4 CYCLE				
	ESEST	ESETS	EESST	EESTS	SEEST	SEETS	ES,TS	ES,ST	SE,TS	SE,ST	FULL 8/4
CSM LUNAR ORBIT TIME	66	58	66	58	66	58	58	66	58	66	62
LUNAR SURFACE TIME	28	28	28	28	28	28	28	28	28	28	32
MAX. TIME BET. SLEEPS	17.5	22.5	23.5	23.5	25	20	16	16	21.5	16.5	9
MIN. TIME BET. SLEEPS	16	16	10	15	8.5	8.5	8.5	8.5	8.5	8.5	7.5
PERFORMANCE: TIME SINCE SLEEP											
FOR EVA_1	10.5	10.5	10.5	10.5	3	3	10.5	10.5	3	3	3
FOR EVA_2	3	3	18	18	10.5	10.5	3	3	3	3	3
FOR DOCKING	14	14	6.5	6.5	21.5	21.5	5.5	5.5	13	13	5.5
FOR TEI	3.25	19.75	3.25	12.25	3.25	27.5	11.25	3.25	18.75	3.25	2.25

TABLE 1-TIME MATRIX

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Subject: Analysis of Work/Rest Cycles in the Lunar Environs for the H1 Mission - Case 320

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